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RECONNAISSANCE INVESTIGATION WATER SUPPLY AND WATER QUALITY CONTROL STUDY. SKAGIT RIVER BASIN PUGET SOUND BASIN, WASHINGTON, D.C.

Federal Water Pollution Control Administration
Portland, Oregon

November 1966

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WATER SUPPLY & QUALITY CONTROL STUDY

RECONNAISSANCE INVESTIGATION

SKAGIT RIVER BASIN PROJECT
Puget Sound Basin, Washington

NOVEMBER 1966

NATIONAL TECHNICAL
INFORMATION SERVICE

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration

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RECONNAISSANCE INVESTIGATION

WATER SUPPLY AND WATER QUALITY CONTROL STUDY

SKAGIT RIVER BASIN
PUGET SOUND BASIN, WASHINGTON

A preliminary investigation has been made which discloses no present or foreseeable future need for storage in the Skagit River Basin for municipal and industrial water supply or for flow regulation for control of water quality. Future water requirements and quality projections are based on economic, demographic, and engineering studies.

Prepared at the Request of the

U. S. Army Engineer District, Seattle
Corps of Engineers, Seattle, Washington

By the

U. S. Department of the Interior
Federal Water Pollution Control Administration
Northwest Region, Portland, Oregon

November 1966

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I. INTRODUCTION

A. REQUEST AND AUTHORITY

The District Engineer, U. S. Army Engineer District, Seattle, Washington, in a letter dated August 28, 1963, requested the advice of the U. S. Department of Health, Education, and Welfare concerning the potential needs for storage for water supply and water quality control in the Skagit River Basin, Washington. The request was for a basin-wide reconnaissance investigation.

The water supply portion of this study was made in accordance with the Memorandum of Agreement, dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare relative to the Water Supply Act of 1958, as amended (43 U.S.C. 390b). The water quality control aspects are considered under authority of the Federal Water Pollution Control Act as amended (33 U.S.C. 466 et seq.). Responsibility for these activities was transferred from the Department of Health, Education, and Welfare to the Department of the Interior by Reorganization Plan No. 2 of 1966, effective May 10, 1966.

B. PURPOSE AND SCOPE

The Corps of Engineers requested data on present municipal and industrial (M&I) water supply and water quality control needs in the Skagit River Basin, and on such future requirements as could be estimated within the scope of a reconnaissance study involving 19 possible reservoir sites. These data are to be used to determine the advisability of initiating detailed investigations of specific storage sites at a later time.

The study area covered in this report consists of the portion of the Skagit River Basin in the United States, Whidbey Island, and the coastal sections of Skagit County.

Evaluations include projected conditions to the year 2020, with interim points at 1980 and 2000. An economic base study was prepared for this purpose and is summarized in this report.

A more detailed study of water supply and water quality control needs will be conducted at such time as the Corps of Engineers may request information relating to a specific project site(s).

C. ACKNOWLEDGMENTS

This investigation was aided materially by the U. S. Geological Survey, Washington Pollution Control Commission, Washington Department of Fisheries and Game, Bureau of Sports Fisheries and Wildlife, the engineering firm of R. W. Beck and Associates, and officials and representatives of the cities and towns within the Skagit River Basin. The use of information contained in the bibliography is also acknowledged.

II. SUMMARY of Findings and Conclusions

A. SUMMARY OF FINDINGS

1. The Skagit River Basin is located in northwest Washington on the western slope of the Cascade Range and contains approximately 3,140 square miles of area, 400 of which lie within British Columbia, Canada.

2. There are nineteen potential project sites within the Skagit River Basin (see FIGURE 1). Of these, the sites presently being considered by the Corps of Engineers are the Lower Faber, Lower Sauk, Lower Suiattle, Upper Sauk, Cascade, Copper Creek, and Thunder Creek.

3. The study area includes portions of Skagit, Whatcom and Snohomish Counties lying within the drainage of the Skagit River, the whole of Whidbey Island, and the coastal areas of Skagit County outside of the Skagit River Basin.

4. The average annual runoff of the Skagit River Basin, measured near Mount Vernon (drainage area 3,093 square miles) is 11,950,000 acre-feet. The low mean annual streamflow at this station having a recurrence interval of one-in-ten years, is 12,100 cfs. The minimum flow recorded at this station is 2,740 cfs (October 26, 1942).

5. The economic base of the study area is well diversified, with specialization in agriculture, forest management, fisheries, wood pulp, lumber and wood products, food processing, and oil refining.

6. Rapid growth of population, recreation resort areas and other business has been experienced near Anacortes and on Whidbey Island. In the last twenty years, the island's population has quadrupled.

7. In 1960 the population of the study area was 69,550, with about 44 percent residing in urban areas. Potential exists for considerable population growth. The projected study area population for 1980, 2000, and 2020 is 97,900, 136,400, and 190,700, respectively.

8. Anacortes and the Skagit County Public Utility District (PUD) No. 1 presently serve 37,800 people, which represents about 54 percent of the 1960 population of the study area, and 125 percent of the population of incorporated places. Areas not served by either of these two systems are considered as rural and are served by individual domestic water systems. In addition to serving its own water needs, the municipal system of Anacortes supplies water to the Naval Air Base located on Whidbey Island, the Shell and Texaco oil refineries located on March Point, Scott Paper Company, Northwest Petrochemical Company, General Chemical Company, and the town of LaConner. The Skagit County PUD No. 1 serves the cities of Mount Vernon, Burlington and Sedro Woolley, as well as areas lying west of Mount Vernon and both west and east of Burlington.

9. As of January 1965, consumptive surface water rights in the Skagit River Basin for municipal, industrial, domestic and irrigation purposes amounted to approximately 425 cfs (274.5 mgd).

10. Water use for municipal and domestic purposes in the study area in 1963 averaged 6.8 million gallons per day (mgd). Approximately 75 percent of this water is obtained from Ranney wells utilizing water mainly from ground sources. Total industrial water use during the food processing season in 1963 averaged 15.2 mgd of which 80 percent is estimated to be obtained from ground sources (Ranney wells). The industrial demand has been increasing more rapidly than the municipal demand and from all indications will continue this trend.

11. At the present level of development (19.8 mgd during low river stages, 25.8 mgd during normal river stages) the Anacortes system is very near maximum capacity during peak usage periods. Total demands vary from 18 to 21 mgd.

12. Additional Skagit River source development for Anacortes is being planned which would consist of an intake structure and microfloc treatment plant at Avon with an initial capacity of 20 mgd. This would bring the Anacortes system capacity to 44 mgd.

13. The Skagit County PUD No. 1 has been following a long-range program for development of water supply and is now engaged in the enlargement of Judy Reservoir (located on Cultus River) from 450 million gallons to about 930 million gallons. This enlargement will make available an additional 5 mgd, thus increasing system capacity to about 24.5 mgd.

14. Groundwater sources on Whidbey Island are limited both in quantity and quality. Water supplies on Whidbey Island, obtained from deep wells, are high in mineral content and do not meet recommended standards for palatability.

15. Chemical quality of the Skagit River, although indicating some signs of high iron content (2.0 mg/1) is generally suitable for all instream and withdrawal uses. Organic matter received in the river is adequately assimilated in all reaches of the river during all seasons of the year without detriment to the dissolved oxygen (DO) requirements necessary for fish (7 mg/1) and other aquatic life. Bacteriological quality data indicate that coliform counts have been as high as 24,000 MPN. (See Appendix.)

16. About 19,300 population equivalents (PE) of raw municipal waste and 245,700 PE of raw industrial waste (during the canning season) are produced each day in the major urban-industrial areas of the Skagit River Basin. Raw municipal waste production on Whidbey Island is estimated to be about 20,000 PE; no significant industrial waste is produced on Whidbey Island. After treatment, which for the Skagit River Basin as a whole is approximately 8 percent, 240,300 PE are discharged to the basin's watercourses. On Whidbey Island, the main portion (16,200 PE) of the wastes produced are treated by individual septic tanks. Langley (no treatment) and Oak Harbor (primary and secondary) discharge 3,800 PE to Puget Sound. Future waste loading to the Skagit River is shown in the table below.

Year	Projected Waste (PE)	
	Raw	Discharged
1980	354,400	53,160
2000	476,000	71,500
2020	639,400	96,000

B. CONCLUSIONS

1. By the years 1980, 2000, and 2020, about 85,550, 121,250, and 172,000 persons, respectively, are expected to be served by public water systems in the study area. Anacortes and the Skagit County PUD No. 1 are expected to serve about 90 percent of the projected urbanized populations. The remaining population (about 18,700 by year 2020) will obtain water from individual or private supplies.

2. Municipal, industrial and domestic water supply requirements projected for the Skagit Basin study area are shown in the following table.

Year	Average Annual Demand		Maximum Monthly Demand
1980	23,410 AF	24.01 mgd	35.5 mgd
2000	32,985 AF	33.54 mgd	53.3 mgd
2020	45,910 AF	46.03 mgd	73.4 mgd

3. The developed Anacortes supply of 20 mgd and the Skagit County PUD No. 1 supply of 24.5 mgd, together with more than ample water available by existing water rights (255 mgd) in the study area will meet foreseeable future M&I demands in these service areas.

4. Limited groundwater supplies of questionable quality on Whidbey Island point out the possibility of developing a central water system for this area which would utilize Skagit River water to supplement or replace the existing groundwater sources. In the event detailed engineering investigations reveal that a centralized water system is feasible, sufficient water is available from the natural flow of Skagit River (total available supply about 1,485 mgd) to meet the projected future water demands of Whidbey Island (10.4 mgd).

5. A need for storage for M&I water supply in Federal reservoir proposals within the study area is not indicated at this time as sufficient water (of satisfactory raw quality) is available without storage and can be obtained by water right application.

6. Adequate streamflow is available in Skagit River to maintain suitable water quality for full use of the river. To maintain dissolved oxygen at 7 mg/l, the upper level of quality governed by fish passage and rearing requirements, about 250 cfs would be needed to assimilate the projected 2020 waste load (96,000 PE). A minimum flow greater than that required (at least 2,000 cfs) is expected to be available.

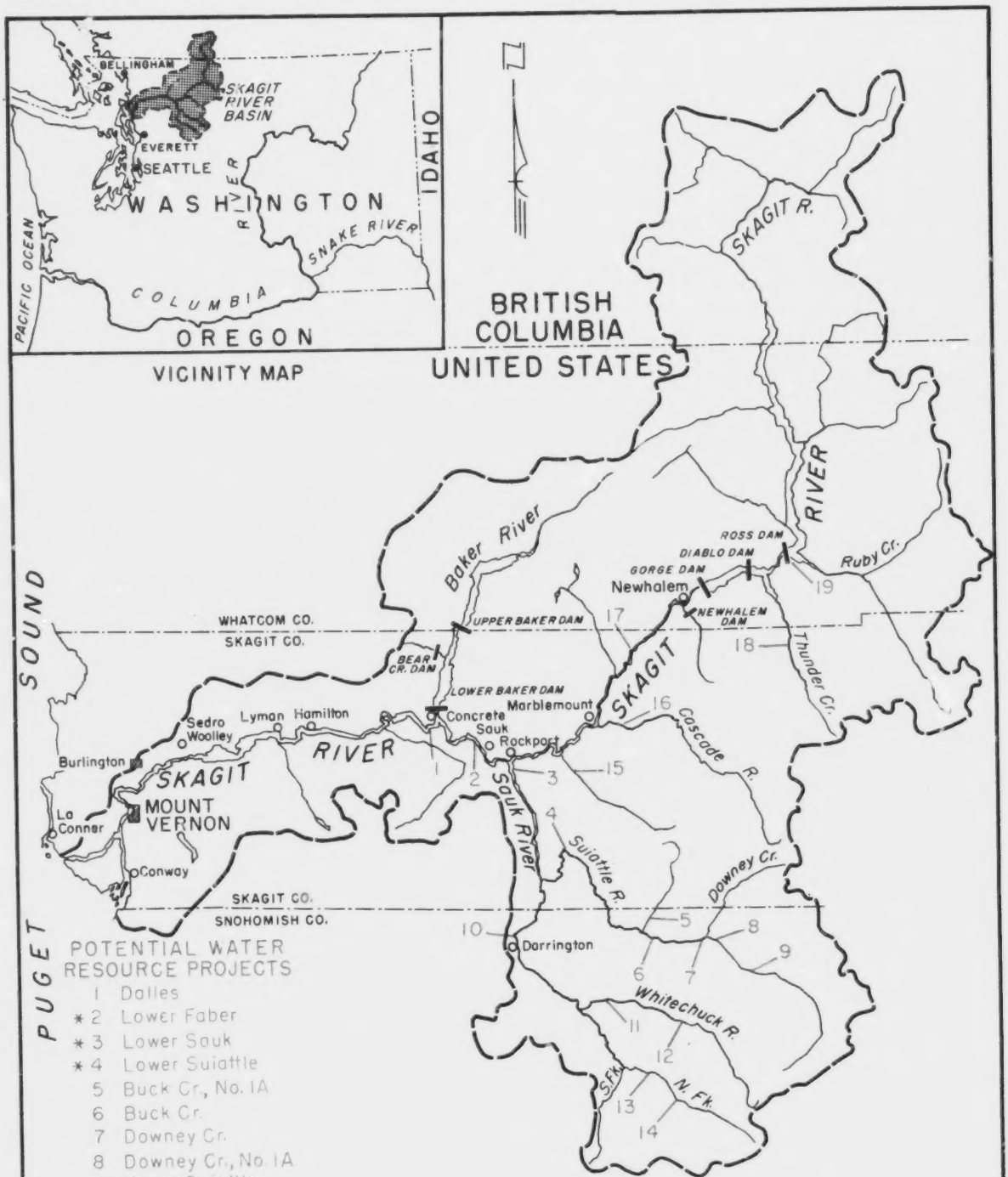
7. As foreseen within the scope of this reconnaissance investigation, no needs for M&I water supply storage and, therefore, no benefits applicable to possible Corps of Engineers' reservoirs in Skagit River Basin for this purpose are indicated at this time.

8. With adequate treatment or other means of controlling waste at the source (85 percent BOD removal) future water quality for municipal and industrial supply, fisheries, wildlife and recreation can be maintained in Skagit River without a draft-on-storage for this purpose. No water quality control benefits applicable to possible Corps of Engineers' reservoirs in Skagit River Basin, therefore, are indicated.

9. Impoundment of water at the potential sites being investigated by the Corps of Engineers in Skagit Basin may produce water quality changes within reservoir areas. These quality changes and the impact of such changes on water uses and values within and downstream of these areas should be evaluated at such time as a specific site(s) is selected for feasibility determination.

III. PROJECT DESCRIPTION

At the present time, a specific project site within the Skagit River Basin has not been selected for a feasibility study by the Corps of Engineers. There are, however, 19 project sites within the basin, as shown in FIGURE 1. Of these sites, those being investigated by the Corps of Engineers as having the greatest potential for multiple-purpose development are the Lower Faber, Lower Sauk, Lower Suiattle, Upper Sauk, Cascade, Copper Creek, and Thunder Creek.



WATER SUPPLY — WATER QUALITY CONTROL STUDY
SKAGIT RIVER WATERSHED
PUGET SOUND BASIN, WASHINGTON

POTENTIAL PROJECTS

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration

REGION IX (DATE 1/67) PORTLAND, OREGON

FIGURE 1

IV. STUDY AREA DESCRIPTION

A. BOUNDARIES

The Skagit River Basin lies on the western slope of the Cascade Range in the northern part of the State of Washington. (See Location Map, back cover.) The basin drains lands extending from British Columbia on the north to the basins of the Stillaguamish and Snohomish Rivers on the south, and easterly from Skagit Bay to the summit of the Cascade Range.

The Skagit River, the largest tributary to Puget Sound, has its source in Canada, 28 miles north of the international boundary, and flows south and then west for 135 miles to Skagit Bay. The largest tributaries to the Skagit are the Sauk, Baker, and Cascade Rivers. The Baker River joins the Skagit at the town of Concrete (RM 49), with the Sauk and Cascade entering further upstream at RM 66 and RM 78, respectively. All three of these major tributary rivers are glacier-fed.

Upper reaches of the basin are in steep, mountainous valleys which broaden but maintain their mountain walls as the river progresses downstream. The river is in a valley from one to three miles wide above Sedro Woolley. Below Sedro Woolley, the valley falls to nearly sea level and widens to a flat, fertile outwash which includes the Samish Valley on the north.

The study area for which water supply and water quality control evaluations have been made includes that portion of Skagit, Whatcom, and Snohomish Counties lying within the drainage of the Skagit River, the coastal sections of Skagit County, and Whidbey Island. The coastal sections which do not lie in the Skagit River drainage area have been included because of their proximity and economic importance.

B. PHYSICAL FEATURES

The Skagit River Basin contains approximately 3,140 square miles, 400 of which lie within British Columbia, Canada. About two-thirds of the basin is in the Mount Baker National Forest, with much of this area being so topographically rough and heavily vegetated that access is very difficult. Elevations range from sea level at Puget Sound to over 10,000 feet at Mount Baker.

C. CLIMATE

Maritime air masses influence both precipitation and temperatures in the Skagit River Basin, producing a mild, wet climate. Approximately 75 percent of the precipitation falls during the period October through March. Recorded mean annual precipitation varies from 106 inches at Mount Baker Lodge to 27 inches at Anacortes. Sedro Woolley, nearly 20 miles further inland than Anacortes, receives 46 inches; and Concrete, in the mountain foothills, receives 62 inches. During the winter, heavy snowfall occurs at higher elevations and remains until late spring or early summer. Average recorded snowfall ranges from 530 inches at Mount Baker Lodge to 5.9 inches at Anacortes.

Growing seasons are long, averaging about 200 days throughout Skagit County. Mean annual temperatures at climatological stations vary from 40.1 degrees Fahrenheit at Mount Baker Lodge to 51.6°F at Concrete, and recorded temperature extremes range from minus 11 degrees Fahrenheit to 106°F at these stations, respectively. The mean annual temperature for the basin is 50°F.

D. PRINCIPAL COMMUNITIES

The principal communities within the study area are Anacortes (8,414), Mt. Vernon (7,900), Burlington (2,968), Sedro Woolley (3,700), and Oak Harbor (4,500).

V. WATER RESOURCES of the Study Area

A. SURFACE WATER

1. Existing Water Resource Development

The Skagit River and tributaries, as indicated on the Schematic Diagram (FIGURE 2) and the Location Map (FIGURE 3, back cover), are the primary water resources of the area. Waters of the river system are used for municipal and industrial water supply by a large segment of the basin's population.

The average discharge of the Skagit River ranges from 4,446 cfs near Newhalem to 16,500 cfs at Mt. Vernon. The maximum recorded discharge at Mt. Vernon was 144,000 cfs (February 11, 1951) and the minimum was 2,740 cfs (October 26, 1942). Base streamflow is normally low from August through March. During the spring months, flow increases due to melting snowcover and normally crests in early June. Winter flows are characterized by frequent sharp rises resulting from concentrated storms or a series of storms. Average yearly streamflows for the Skagit River at Newhalem for the period 1908-1962 have been plotted and are shown in the appendix.

A low flow frequency analysis has been made based on a 24-year period of record at the Mt. Vernon gaging station. The annual average 1-in-10 year low flow which may be expected to occur at this station has been determined to be 12,100 cfs. The minimum monthly 1-in-10 year low flow, occurring in the month of September, has been determined to be 6,550 cfs.

2. Water Rights

Surface water rights in the Skagit River Basin, as of January 1965, for municipal, industrial and domestic water supply and irrigation purposes are summarized in the adjacent table. The city of Anacortes has rights to 135.0 cfs (87 mgd) on the Skagit River, 4 cfs (2.6 mgd) from Lake Erie, and 1,000 acre-feet per year (0.9 mgd) from Lake Campbell. The Skagit County PUD No. 1 has two water right applications on Day Creek to divert a total of 62 cfs (40 mgd), an application on the East Fork of Nookachamps Creek for 15.2 cfs

USE	QUANTITY	
	cfs	AF
Municipal Water Supply	267.10	16,950
Industrial Water Supply	42.75	42
Domestic Water Supply	83.27	--
Irrigation Water Supply	31.17	--
Totals	424.29	16,992

(9.7 mgd), nine applications on various creeks for a total of 53.4 cfs (34.4 mgd) and 16,950 acre-feet of storage.

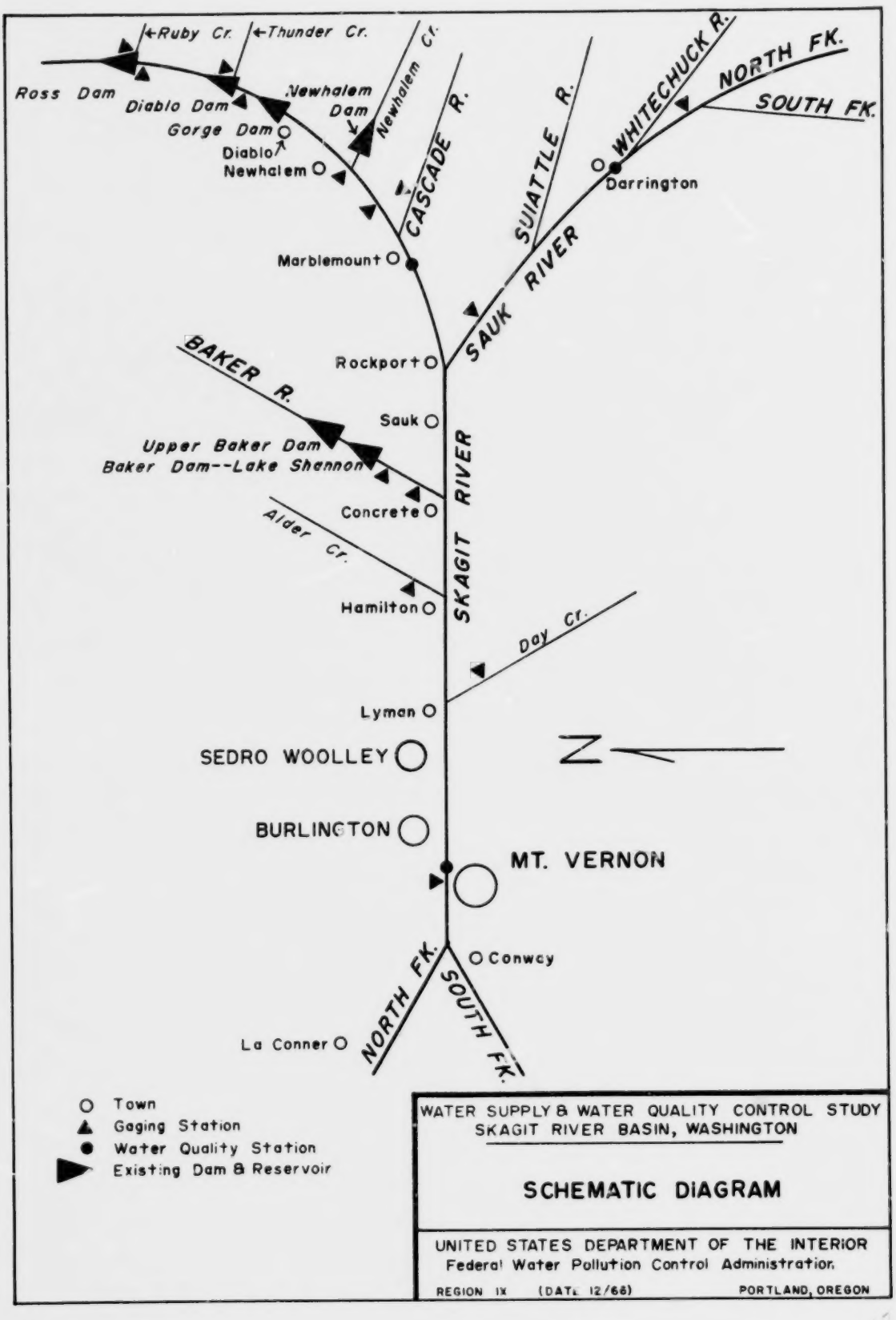
3. Water Quality

Water quality data (Appendix A) for the Skagit River near Mt. Vernon indicate generally high coliform bacteria concentrations during July and August and during the late fall months. The higher coliform concentrations during July and August are probably due to less dilution of upstream municipal wastes by the low natural flows in the river. The high coliform concentrations at Mt. Vernon during the fall are believed to reflect the effect of runoff from the lower valley during the early fall rains. The lower flood plain is extensively used for dairying, and livestock wastes washed into the river by these rains contribute to the total bacterial count in the river.

Most probable numbers (MPN) of coliform organisms were as high as 24,000 per 100 ml at Mt. Vernon during August in both 1962 and 1963. Typical values during the winter months, however, were around 100 to 300, with counts ranging between 91 MPN and 2,400 MPN during this time. A low value of 3 MPN was recorded during June 1962.

Temperatures of the Skagit River rarely exceed 60°F, according to the data available on lower reaches of the river near Mt. Vernon. Data also show that DO remains close to saturation values in all reaches of the river. A low value of 9.3 mg/l (September 6, 1961) and a high value of 13.7 mg/l (December 6, 1942) have been recorded for the Skagit River near Mt. Vernon.

The color of Skagit River water near Mt. Vernon is influenced by colloidal suspensions originating from glacial melt. The Suiattle River, a tributary of the Sauk River, carries a large portion of the glacial flour that influences color. Data show color values ranging between 5 and 20 units.


←Ruby Cr.
←Thunder Cr.
Newhalem Cr.
Ross Dam
Diablo Dam
Newhalem Dam
Gorge Dam
Diablo
Newhalem
CASCADE R.
SUIATTLE R.
WHITECHUCK R.
NORTH FK.
SOUTH FK.
Darrington
Marblemount
SAUK RIVER
BAKER R.
Rockport
Sauk
Upper Baker Dam
Baker Dam--Lake Shannon
Concrete
SKAGIT RIVER
Alder Cr.
Hamilton
Day Cr.
Lyman
SEDRO WOOLLEY
N
BURLINGTON
MT. VERNON
Conway
NORTH FK.
SOUTH FK.
La Conner
Town
Gaging Station
Water Quality Station
Existing Dam & Reservoir
WATER SUPPLY & WATER QUALITY CONTROL STUDY
SKAGIT RIVER BASIN, WASHINGTON
SCHEMATIC DIAGRAM
UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
REGION IX (DATE 12/68) PORTLAND, OREGON

B. GROUNDWATER

In the Skagit River Basin, groundwater is found at relatively shallow depths. Yields appear to be adequate for present and foreseeable needs. The chemical and bacteriological quality of Ranney well water supplies in the study area generally meet recommended quality standards for drinking water and are considered of adequate quality for continued use. The usual raw water iron content is 1.5 mg/l, but varies with river stages from 0.5 to 2.5 mg/l. Facilities for iron removal and disinfection for bacterial control have been provided. Groundwater on Whidbey Island, however, is limited both in quantity and quality. Localities on the island have experienced problems with yields due to intrusion of sand, etc. into the wells. Quality problems have also been experienced.

Quality data on the water supply of the city of Coupeville, located on the southern end of Whidbey Island, indicate excessively high dissolved solids, hardness, and specific conductance. Very recently the community of Clinton experienced bacterial contamination in the water supply necessitating the installation of disinfection equipment. Groundwater quality data for five wells in Island County are presented in Appendix C.

VI. THE ECONOMY

A. GENERAL

The demand for water for municipal and industrial purposes, and the amount and character of waste waters resulting from such uses, are determined largely by the activities associated with a region's economic base. The purpose of this section is to present economic and demographic data to be used as a basis for projecting the needs for water for municipal and industrial purposes and for estimating the future amounts and types of waste and land drainage material that may be expected to occur in the Skagit River Basin with the expanded development anticipated in the future.

B. PRESENT

1. Economic Activities

The economic base of Skagit County is well diversified, with specialization in agriculture, forest management, fisheries, lumber and wood products, food processing and oil refining. Aside from these categories, in which employment in Skagit County is proportionately larger than in the United States, there is also significant employment in machinery manufacturing and in pulp and paper. The above-average employment in construction is not considered to be part of the permanent economic base, but rather to result from temporary construction activity under way at the time of the 1960 census. Employment in service industries is somewhat below average, because Skagit County is part of the Seattle metropolitan area, which provides many service functions for Skagit County. Employment, by major industry, in Skagit County in 1960 is shown in TABLE VI-1.

The economic aspects on Whidbey Island center mainly around farming and related agricultural activities. The area was at one time a large producer of turkeys but, in recent years, production has diminished to a great extent. Except for the northern portion of the island centered mainly in the vicinity of Oak Harbor and the Naval Air Station, Whidbey Island is characteristically rural in nature with many small farms. The development of resorts along the coastal areas has increased substantially in the past few years and further development potential suggests increased activity along these lines.

TABLE VI-1

LABOR FORCE, BY MAJOR INDUSTRY, SKAGIT COUNTY, APRIL, 1960

Industry	Number Employed April, 1960	Percentage Distribution	
		Skagit County	U.S.
Agriculture	2,000	10.5	6.1
Forest Management & Fisheries	161	0.8	0.1
Mining	21	0.1	0.9
Manufacturing, TOTAL	4,307	22.6	25.1
Logging, Lumber & Wood Products	1,581	8.3	1.5
Primary & Fabricated Metals	36	0.2	3.6
Machinery (incl. electrical)	358	1.9	4.4
All Other Durables	286	1.5	4.6
Food Processing	743	3.9	2.6
Textiles & Apparel	12	0.1	3.1
Printing & Publishing	161	0.8	1.6
Chemicals	36	0.2	1.2
Pulp & Paper	125[a]	0.6	0.7[d]
Petroleum Refining	820[b]	4.3	0.2[d]
All Other Non-Durables & Misc.	149[c]	0.8	1.6[d]
Construction	1,360	7.1	5.5
Services	9,420	49.5	54.8
Military	165	0.9	2.5
Unemployed	1,627	8.5	5.0
TOTAL LABOR FORCE	19,061	100.0	100.0

a/ Estimate for Scott Paper Co. mill at Anacortes.

b/ Estimate for Shell Co. refinery (55,000 barrels/day) & Texaco Co. refinery (45,000 barrels/day), in Anacortes, based upon a ratio of 122 barrels/day per employee, which was the 1960 average for the State of Washington.

c/ Estimated as a residual after deducting pulp & paper & petroleum refining employment from U.S. Census figure for "other non-durables" group.

d/ Estimated from data for 1960 from "1961 Annual Survey of Manufacturers", U. S. Department of Commerce, November, 1962.

SOURCE: U. S. Census of Population.

2. Population

In April 1960, the labor force of 19,061 persons supported a total county population of 48,419, or a ratio of 2.54 to 1, population to total labor force. TABLE VI-2 shows the distribution of Skagit County population among incorporated and unincorporated portions.

TABLE VI-2

POPULATION, INCORPORATED AND UNINCORPORATED AREAS, SKAGIT COUNTY, APRIL, 1960

City or County	Population
Incorporated Places:	
Anacortes	8,414
Burlington	2,968
Concrete	840
Hamilton	271
LaConner	638
Lyman	400
Mt. Vernon	7,921
Sedro Woolley	3,705
Subtotal, Incorporated Places	25,157
Unincorporated Area	26,193
TOTAL, SKAGIT COUNTY	51,350

Source: U. S. Census of Population

In 1960 the population of Whidbey Island was 18,200. The Naval Air Station at Oak Harbor, and the towns of Oak Harbor, Coupeville, Clinton and Langley in 1960 accounted for 36 percent of the island's population. The remaining portion is considered to be rural. TABLE VI-3 shows the distribution of Whidbey Island population among incorporated and unincorporated portions.

TABLE VI-3

POPULATION, INCORPORATED AND UNINCORPORATED AREAS
WHIDBEY ISLAND, ISLAND COUNTY

April, 1960

City	Population
Incorporated Places:	
Oak Harbor	3,942
Coupeville	740
Langley	448
Unincorporated Area	13,070
TOTAL, WHIDBEY ISLAND	18,200

Source: U. S. Census of Population

C. FACTORS INFLUENCING FUTURE GROWTH

The major source of future economic growth is expected to be attributable to expansion of industry and the same basic resources and locational advantages that are now the support of the economy. No increase, however, in total seafood harvest or processing is anticipated during the study period. As potentials for increased agriculture exist, greater volumes of fruit and vegetable processing and preparation of dairy products are anticipated. It is expected that the output volume (other than seafood) at food processing plants will increase at a rate of about 1.5 percent per year, which is slightly below the rate of increase during the 1950-60 period. Utilizing this growth rate, 1980 volume will be 135 percent of 1960 volume, 2000 volume will be 180 percent of that of 1960, and 2020 volume will be 240 percent of the 1960 volume. Timber harvest is expected to remain at present levels, or decline slightly, during the study period. With usage shifting away from sawmills to pulp and plywood, it is expected that raw materials for pulp will be shipped to plants outside Skagit County. As a result of growth in demand, petroleum refining capacity at Anacortes is expected to double by the year 2000. Alder pulp production at the Scott Paper plant in Anacortes, an old, small plant, is expected to cease by 1980, with the raw material going to Everett. Service industry employment and diversified manufacturing are also expected to increase.

D. FUTURE

1. Future Employment

Based on the above considerations, the projected future labor force is presented in TABLE VI-4. In deriving the projections in TABLE VI-4 it has been assumed that increases in output in many industries (such as agriculture, mining, food processing, oil refining) will be at least partially offset by increasing hourly productivity. It has also been assumed that construction employment will gradually approach the present national proportion (about 5.5 percent of total labor force), and that unemployment in Skagit County will also gradually approach the present national proportion (about 5 percent). In TABLE VI-4 it has been assumed that services will increase to about 60 percent of the total labor force by 2020, which is consistent with the strong trend in this direction in recent decades throughout the nation.

TABLE VI-4

ILLUSTRATIVE DISTRIBUTION, BY MAJOR INDUSTRY,
FUTURE LABOR FORCE, SKAGIT COUNTY

Industry	Employment, Nearest Thousand			
	1960	1980	2000	2020
Agriculture	2.0	2.0	2.0	2.0
Forest Management & Fisheries	0.2	0.3	0.4	0.5
Mining	a/	0.1	0.1	0.1
Manufacturing, TOTAL	4.3	5.2	6.1	7.0
Logging, Lumber & Wood Products	1.6	1.6	1.6	1.6
All Other Durables	0.7	0.9	1.2	1.5
Food Processing	0.7	0.9	1.1	1.3
Printing & Publishing	0.2	0.4	0.5	0.6
Petroleum Refining	0.8	0.9	1.0	1.1
All Other Non-Durables & Misc.	0.3	0.5	0.7	0.9
Construction	1.4	1.4	1.5	1.6
Services	9.4	12.2	15.5	19.7
Military	0.2	0.2	0.3	0.3
Unemployed	1.6	1.4	1.4	1.4
TOTAL LABOR FORCE	19.1	22.3	27.3	32.6

a/ Less than 50.

2. Future Population

It is expected that the ratio of population to total labor force in the nation as a whole and in Skagit County and Whidbey Island will increase during the study period as a result of earlier retirement, longer periods of schooling, and an increase in the percentage of population in the higher age brackets. For Skagit County it has been assumed that the ratio will increase from 2.69-to-1 in 1960 to 2.8-to-1 in 1980, 2.9-to-1 in 2000 and 3.1-to-1 in 2020. On this basis, the total Skagit County labor force projected in TABLE VI-4 would support a population of 62,800 by 1980, 78,300 by 2000, and 99,400 by 2020*, representing a growth rate of 1.2 percent per year over the study period. Although growth is expected to occur in the western portion of the county, to arrive at projected population, the growth rate has been applied to both the incorporated and unincorporated areas excepting the rural portion which was assumed to remain constant. The projected Skagit County population is shown in TABLE VI-5.

Population growth on Whidbey Island over the past two decades has been quite rapid. During each of these two periods the population about doubled, reflecting a very high growth rate. Because of this high growth rate in the past, and the general trend of increase, the population of Whidbey Island is expected to grow at a faster rate than for Skagit County as a whole. This reflects the substantial anticipated residential growth in the northern sections of the island in the vicinity of Oak Harbor. Growth in resort areas along the coast is also anticipated to be high. Growth rates of 3.1 percent per year from 1960 to 1980 and about 2.5 percent from 1980 to 2020 have been applied in deriving the population projections for the island. The projected population for Whidbey Island is also shown in TABLE VI-5.

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* These figures are slightly lower than the projections for Skagit County given in the "North Cascade Mountains Study" of CBIAC, published January 31, 1964, because total U. S. population projections were revised downwards since the preparation of that CBIAC study, with a corresponding reduction in the projected total for Washington State.

TABLE VI-5
PROJECTED POPULATION, SKAGIT COUNTY
INCORPORATED & UNINCORPORATED AREAS

City or County	Population, Thousands 1960	1980	2000	2020
SKAGIT COUNTY				
Incorporated Places:				
Anacortes	8.4	10.6	13.5	17.1
Burlington	3.0	3.8	4.8	6.1
Concrete	0.8	1.0	1.3	1.6
Hamilton	0.3	0.4	0.5	0.7
LaConner	0.6	0.8	1.0	1.3
Lyman	0.4	0.5	0.6	0.8
Mt. Vernon	7.9	10.0	12.7	16.1
Sedro Woolley	3.7	4.7	6.1	7.7
Subtotal, Incorporated Places	25.1	31.8	40.5	51.4
Unincorporated Places	24.1	30.6	38.8	49.2
Rural	2.1	2.1	2.1	2.1
SKAGIT COUNTY	51.3	64.5	81.4	102.7
WHIDBEY ISLAND				
Incorporated Places:				
Oak Harbor	4.5	8.4	13.7	22.4
Coupeville	1.2	2.2	3.6	5.9
Langley	0.5	0.8	1.4	2.2
Subtotal, Incorporated Places	6.2	11.4	18.7	30.5
Unincorporated Area	12.0	22.0	36.3	57.5
WHIDBEY ISLAND	18.2	33.4	55.0	88.0
TOTAL STUDY AREA	69.5	97.9	136.4	190.7

VII. WATER REQUIREMENTS
Municipal & Industrial

A. PRESENT WATER USE

At the present time, the municipal and industrial water demands generated within the study area amount to approximately 21,900 acre-feet per year or an average of 22.0 mgd. The industrial water demand (14,260 acre-feet per year) accounts for about 65 percent of the total annual average M&I demand. The two major water systems, Anacortes and the Skagit County PUD No. 1, satisfy about 92 percent of the total M&I demand, serving the needs of approximately 30 major water using industries which vary from food processing to oil refining and paper manufacturing. The Anacortes system alone provides about 75 percent of the total M&I demand, and is by far the largest water purveyor in the study area.

Maximum monthly M&I demands for the study area, including the food processing demands, have been estimated to be 28.1 mgd. Municipal and Industrial water consumption records for the period 1960 to 1963 for the Anacortes water system and the Skagit County PUD No. 1 system were utilized in determining the present level of water usage. Average and maximum M&I usage for Anacortes and the Skagit County PUD No. 1 are shown in TABLE VII-1.

TABLE VII-1
MUNICIPAL AND INDUSTRIAL WATER CONSUMPTION
ANACORTES AND SKAGIT COUNTY PUD NO. 1

System	Ave. Annual Consumption mgd	Max. Month 1/ Consumption Month	mgd	Max. Month as % of Average Annual
Anacortes:				
Municipal	2.3	July	3.3	145
Industrial	12.0	Jan.	12.9	107
Skagit County PUD No. 1:				
Municipal	1.7	Aug.	2.6	150
Industrial	1.3	Sept.	3.2	245

1/ Based on four years of record 1960-63).

Present M&I water usage for the Skagit River Basin study area is shown in TABLE VII-2.

TABLE VII-2
MUNICIPAL, INDUSTRIAL AND DOMESTIC WATER DEMANDS
SKAGIT RIVER BASIN STUDY AREA
1963

Service Area	Population Served	Ave. gpcd	Ave. mgd	Annual Acre-Feet
Anacortes (Municipal)	10,000	123	1.23	1,380
Whidbey Island Naval Air Base	4,800	200[1/]	0.96	1,080
Shell Oil	---	---	3.30	3,700
Texaco Oil	---	---	3.30	3,700
Scott Paper	---	---	5.30	5,950
N.W. Petrochemical	---	---	0.03	35
General Chemical	---	---	0.05	55
LaConner (Food Processing)[3/]	---	---	0.21	55
Skagit County PUD No. 1				
Municipal	27,800	63	1.75	1,960
Food Processing[3/]	---	---	3.00	750
Other Municipal Systems				
Clear Lake, Concrete, Conway, Darrington, Diablo, Hamilton, Lyman, Newhalem, Rockport	4,800	100[2/]	0.48	540
Other Domestic[4/]	8,400	100[2/]	0.84	940
Rural	2,100	100[2/]	0.21	235
Whidbey Island (excludes Naval Air Base)	13,400	100[2/]	1.34	1,500
TOTALS	71,300		22.00	21,885

1/ Estimated: Served by Anacortes

2/ Estimated

3/ Three month season

4/ Population residing in suburban areas of communities and served by individual domestic water systems.

B. EXISTING SOURCE DEVELOPMENT

The Anacortes system supplies water to an estimated 10,000 persons. In addition to serving its own water needs, the municipal system of Anacortes supplies water to the Naval Air Base located on Whidbey Island, the Shell and Texaco oil refineries located on March Point, Scott Paper Co., Northwest Petrochemical Co., General Chemical Co., and the town of LaConner. The water supply is obtained primarily from two Ranney wells located in the vicinity of Avon on the east bank of the Skagit River north of Mt. Vernon. The well supply is at times supplemented with Skagit River water by pumping from the river into the Ranney wells. The water, after treatment for iron removal, is pumped through a transmission line across the Swinomish flats for about twelve miles to a reservoir located on a high level in the city. The combined capacity of the Ranney wells during low river stages is 14.8 mgd (20.8 mgd at normal river stages) and that of the surface water pumping plant is 5 mgd. Peak daily usage has reached 24 mgd. During these peak periods, the present distribution system including storage is barely able to keep up with demands.

Additional Skagit River source development for Anacortes is being planned which would consist of an intake structure and microfloc treatment plant at Avon with an initial capacity of 20 mgd along with increased transmission capacity.

The city of Anacortes has been considering cleaning and enlarging Whistle Lake located on Fidalgo Island southwest of town. The lake and watershed, used years ago as a water supply, is owned by the city. The capacity could be increased from 410 mg to 672 mg, which would provide an emergency supply should the transmission line from the river be out of service.

The Skagit County PUD No. 1 supplies water to an estimated 27,800 people located in Mt. Vernon, Burlington, Sedro Woolley, the rural areas west of Burlington and Mt. Vernon and the Clear Lake area east of Burlington. An isolated system serves the communities of Similk Beach, Dewey Beach and Deception Pass, located on Fidalgo Island.

The existing PUD water supply is obtained principally from the Cultus Mountain watershed. Surface water from this area is impounded in Judy Reservoir. As a secondary source of supply, the PUD has a Ranney well located in the vicinity of Mt. Vernon (4 mgd), a conventional well in Sedro Woolley (1 mgd), and a 2 mgd filtration plant on the Skagit River. Three small wells (combined capacity 80 gpm) serve the area on Fidalgo Island.

The Skagit County PUD No. 1 has been following a long-range program for development of water supply and is engaged in the enlargement of the capacity of Judy Reservoir from 450 mg to about 930 mg. The present capacity of the system is about 19.5 mgd (Ranney well, 4 mgd; Sedro Woolley well, 1 mgd; treatment plant on river, 2 mgd; transmission line from Judy Reservoir, 12.5 mgd). The enlargement is expected to make available an additional 5 mgd, increasing system capacity to about 24.5 mgd. In addition, a USGS study on Day Lake and Day Creek indicates that 80 to 100 mgd could be made available from this area. The areas which are not supplied by either Anacortes or the Skagit County PUD No. 1 utilize groundwater. Only 900 people in these outlying areas use surface water as a primary or supplemental source.

The 35 water systems located on Whidbey Island all utilize groundwater as the source of supply. Problems associated with these well supplies on Whidbey Island have led to the development of plans for a central water system for the entire island which, as presently foreseen, would obtain water from the Skagit River.

An inventory of municipal and industrial water supplies for the Skagit River Basin and Whidbey Island is located in Appendix B.

C. FORECAST OF FUTURE WATER NEEDS

The major water demands for municipal, industrial and domestic uses will continue to be generated in the urbanized western section of the study area. By the end of the study period, study area water demands will average about 46 mgd, and the maximum monthly demand which occurs during the food processing season and which includes water for this purpose will be about 65.4 mgd.

By the years 1980, 2000, and 2020, about 97,900, 136,400, and 190,700 persons, respectively, are expected to be served by the public water systems, with Anacortes and the Skagit County PUD No. 1 serving about 90 percent of the projected 2020 urbanized populations.

As national and study area trends have shown increases in per capita demands (about one gallon per capita per day per year), an allowance for per capita increases was made in this study.

Water requirements for the oil refining, chemical and food processing industries, for 1980, 2000 and 2020, reflect the expected doubling of production levels for these industries by the year 2000. Water usage is expected to increase in proportion to projected output.

Water requirements for the Scott Paper Mill at Anacortes have not been projected since it is expected that this plant will be idled before the year 1980.

Based on projected populations, municipal per capita demands, projected industrial production and production unit water requirements, the total annual water requirements for M&I water supply purposes for the years 1980, 2000, and 2020 for the study area are forecast to be 24.01, 33.54, and 46.03 mgd, respectively. A breakdown of these requirements is shown in TABLES VII-3, VII-4, and VII-5.

TABLE VII-3
MUNICIPAL, INDUSTRIAL AND DOMESTIC WATER DEMANDS
SKAGIT RIVER BASIN STUDY AREA
1980

Service Area	Population Served	Aver. gpcd	Aver. mgd	Annual Acre-Feet
Anacortes (Municipal)	12,250	145	1.78	2,000
Whidbey Island Naval Air Base	5,900	200[2]	1.18	1,320
Oil Refining	---	---	8.80	9,880
Petrochemicals	---	---	0.11	125
Food Processing[1]	---	---	0.33	90
Skagit County PUD No. 1				
Municipal	34,100	85	2.90	3,240
Food Processing[1]	---	---	4.00	1,120
Other Municipal Systems				
Clear Lake, Concrete, Conway, Darrington, Diablo, Hamilton, Lyman, Newhalem and Rockport	5,900	110[2]	0.65	730
Other Domestic[3]	10,250	110[2]	1.13	1,265
Rural	2,100	110[2]	0.23	260
Whidbey Island (excludes Naval Air Base)	27,400	110[2]	3.02	3,380
TOTALS	97,900		24.01	23,410

[1] Three month season.
[2] Estimated.
[3] Population residing in suburban areas of communities and served by individual domestic water systems.

TABLE VII-4
MUNICIPAL, INDUSTRIAL AND DOMESTIC WATER DEMANDS
SKAGIT RIVER BASIN STUDY AREA
2000

Service Area	Population Served	Aver. gpcd	Aver. mgd	Annual Acre-Feet
Anacortes (Municipal)	15,550	165	2.57	2,880
Whidbey Island Naval Air Base	7,000	200[2]	1.40	1,570
Oil Refining	---	---	11.00	12,320
Petrochemicals	---	---	0.14	155
Food Processing[1]	---	---	0.41	110
Skagit County PUD No. 1				
Municipal	43,200	105	4.55	5,080
Food Processing[1]	---	---	5.00	1,390
Other Municipal Systems				
Clear Lake, Concrete, Conway, Darrington, Diablo, Hamilton, Lyman, Newhalem and Rockport	7,500	120[2]	0.90	1,010
Other Domestic[3]	13,050	120[2]	1.57	1,760
Rural	2,100	120[2]	0.25	280
Whidbey Island (excludes Naval Air Base)	48,000	120[2]	5.75	6,430
TOTALS	136,400		33.54	32,985

[1] Three month season.
[2] Estimated.
[3] Population residing in suburban areas of communities and served by individual domestic water systems.

The availability of water to meet projected demands is shown by gaging data on the Skagit River, in the vicinity of Mt. Vernon. These data indicate that the minimum flow of record is 2,740 cfs (October 26, 1942), which is more than adequate to meet all existing water rights and expected future withdrawals in the urbanized sections of the study area. The developed Anacortes supply of 20 mgd and the Skagit County PUD No. 1 supply of 24.5 mgd, together with more than ample water available by existing water rights (255 mgd) in the study area will meet foreseeable future M&I demands in these service areas.

Limited groundwater supplies of questionable quality on Whidbey Island, however, point out the possibility of developing a central water system for this area which will utilize Skagit River water to supplement or replace the existing groundwater sources. In the event that a centralized water system is found to be feasible by detailed engineering study, sufficient water is available from the Skagit River (total available supply - 1,485 mgd) to meet the projected future water demands of Whidbey Island (10.4 mg).

A need for storage for M&I water supply in Federal reservoir proposals within the study area is not indicated at this time as sufficient water (of satisfactory raw quality) is available without storage and can be obtained by water right applications.

TABLE VII-5
MUNICIPAL, INDUSTRIAL AND DOMESTIC WATER DEMANDS
SKAGIT RIVER BASIN STUDY AREA
2020

Service Area	Population Served	Aver. gpcd	Aver. mgd	Annual Acre-Feet
Anacortes (Municipal)	19,700	185	3.65	3,940
Whidbey Island Naval Air Base	8,000	200[2]	1.60	1,800
Oil Refining	---	---	13.20	14,800
Petrochemicals	---	---	0.16	180
Food Processing[1]	---	---	0.50	135
Skagit County PUD No. 1				
Municipal	54,800	125	6.85	7,680
Food Processing[1]	---	---	6.00	1,670
Other Municipal Systems				
Clear Lake, Concrete, Conway, Darrington, Diablo, Hamilton, Lyman, Newhalem and Rockport	9,500	130[2]	1.24	1,380
Other Domestic[3]	16,600	130[2]	2.16	2,420
Rural	2,100	130[2]	0.27	305
Whidbey Island (excludes Naval Air Base)	80,000	130[2]	10.40	11,600
TOTALS	190,700		46.03	45,910

[1] Three month season.
[2] Estimated.
[3] Population residing in suburban areas of communities and served by individual domestic water systems.

VIII. WATER QUALITY CONTROL

A. NEED FOR CONTROL

1. General

The water uses in the Skagit River Basin which have quality requirements are municipal and industrial (M&I) water supply, irrigation, fisheries, wildlife, and recreation.

Since the Skagit River and tributaries contribute importantly to commercial and sport fisheries and to recreational and aesthetic values in the region, waste treatment and any needs for flow regulation for water quality control will continue to be governed by dissolved oxygen and temperature requirements for the protection and/or enhancement of these uses.

2. Municipal and Industrial Water Supply

M&I water supply in the Skagit River Basin is primarily obtained from groundwater (see Chapter VII). The chemical quality of both ground and surface waters for this purpose is generally within the limits of the U. S. PHS Drinking Water Standards. At times, however, high turbidity and high iron content prevail.

With the exception of turbidity and possibly iron, available data indicate that the quality of Skagit River water is satisfactory for M&I use. Treatment of this water by coagulation, sedimentation, and filtration, or the equivalent, together with continuous post-chlorination, would be required, however, to produce a potable supply.

Coliform counts are generally low, but have been as high as 24,000 MPN in the lower river during August in both 1962 and 1963, indicating a need for a higher level of waste disinfection or bacterial control at the source.

Objectives established by the Pacific Northwest Pollution Control Council for raw water requiring complete conventional treatment for drinking and food processing purposes state that MPN coliform organisms should average less than 2,000 per 100 milliliters (ml) and should not exceed this number in more than 20 percent of samples examined in any one month. During most of the year, the desired objective of 2,000 MPN is met. The fact that the MPN has, on occasion, exceeded this value does not preclude use of the river as a source of raw water for M&I purposes since additional treatment of the raw water source could be provided.

Groundwater in the study area is an important source for M&I water supply. About 75 percent of the total water used for M&I purposes is obtained from this source. The municipal water needs of the city of Anacortes and industrial requirements of the oil refineries located on March Point are met from groundwater obtained from two Ranney wells located near the Skagit River in the vicinity of Avon. Many of the smaller towns in the study area also utilize groundwater for supply purposes. Water supplies on Whidbey Island are all obtained from ground sources. Thirty-five water supply systems in operation on the island serve a total population of about 14,300.

3. Irrigation

Irrigation in the Skagit River Basin is practiced primarily on farmlands west of Mt. Vernon. At the present time in the Skagit River Basin, about 6,000 acres are under irrigation. By 1980, it is estimated that approximately 10,000 acres will be irrigated and during the period 2000 to 2020, 35,000 acres are expected to be irrigated. At the present time, 2,100 acres are under irrigation on Whidbey Island. No increase in irrigated acreage on the island is foreseen for the future. Quality of waters in the study area is suitable for irrigation purposes.

4. Fisheries

The Skagit River is the largest producer of anadromous fish in the Puget Sound system. Large runs of pink, chinook, coho, chum and sockeye salmon, occurring in all months of the year, support significant commercial and sport fisheries in Skagit Bay and River. The estimated average effort of the sport fishery is 46,000 angler-days. Preliminary information prepared by the Bureau of Sports Fisheries and Wildlife indicate that the annual sport catch is 17,000 salmon. In 1963 and 1964, an average of 18,000 chinook salmon were caught commercially in the Skagit Bay area.

The largest sport catch of steelhead trout in the State usually comes from the Skagit River. Also present are resident and searun cutthroat trout, whitefish, rainbow, brook, brown and Dolly Varden trout.

5. Recreation

The many lakes and streams in the study area, along with Puget Sound, offer excellent opportunities for water-oriented recreation. In the reservoir areas and in Puget Sound, recreation is increasing and may be expected to reach larger proportions.

The Corps of Engineers' authorized Avon Bypass project would create a lake eight miles long within two miles of Mt. Vernon and Burlington. In addition to opportunities for boating, plans have been developed for a resident trout fishery within the Bypass which will provide considerable opportunity for increased recreational use in the area. It has been estimated that the Bypass would initially attract 60,000 visitors annually and, within 50 years, could well attract 750,000 visitors annually.

B. MUNICIPAL, INDUSTRIAL AND AGRICULTURAL POLLUTION

It is estimated that 265,000 population equivalents (PE) of raw M&I waste* are produced per day in the major population and industrial areas in the Skagit River drainage area and that, after treatment, 90 percent, or 240,300 PE, are discharged to the stream waters. Municipal and industrial wastes originating in Anacortes and on Whidbey Island are discharged to adjacent Puget Sound waters and are not involved, therefore, in the studies relating to needs for flow regulation for water quality control in the Skagit River Basin study area. Food processing wastes constitute the major seasonal load received in the Skagit River (about 228,000 PE).

Total raw waste production on Whidbey Island is estimated to be about 20,000 PE. The municipal systems of Langley and Oak Harbor discharge about 3,800 PE to Puget Sound. The remaining wastes produced on Whidbey Island are treated by individual septic tanks.

Waste treatment practices in the area consist of septic tanks, primary and secondary sewage treatment works, industrial lagoons, and industrial waste disposal by land application. About 1.6 percent of the total waste produced is disposed of by land application. Burlington provides secondary waste treatment, with the rest of the towns in the study area providing primary treatment.

Total raw municipal waste produced in the Skagit River Basin is about 19,300 PE and, after treatment, about 12,000 PE are discharged to the Skagit River, as shown in TABLE VIII-1. The only untreated municipal waste discharged to the Skagit River is from the town of Concrete.

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* Measured in terms of five-day bio-chemical oxygen demand (BOD_5)

TABLE VIII-1
RAW AND DISCHARGED MUNICIPAL WASTES, SKAGIT RIVER BASIN

Plant or Municipality	River Mile	PE Raw	PE Discharged
Diablo Hollywood Plant	101	125	90
Reflector Bar Plant	101	140	100
Newhalem	94	225	180
Darrington (on Sauk River)	67-20	-	No System
Concrete	54	200	200
Sedro Woolley	23	6,000	4,200
Burlington	18	3,600	1,000
Mount Vernon	11	9,000	6,300 a/
TOTAL			12,070

a/ Does not include seasonal canning wastes.

The raw industrial food processing waste produced per day in the Skagit River Basin is estimated to be 245,700 PE. A list of industrial plants and waste loads is shown in TABLE VIII-2 and is summarized under "Present" in TABLE VIII-3.

With the installation of adequate treatment and in-plant waste control techniques to accomplish at least 85 percent BOD reduction, future loading to the Skagit River would be less than exists at the present time (i.e., 53,160 PE by 1980, 71,500 PE by 2000, and 96,000 PE by the year 2020).

In addition to the direct water-carried waste discharges discussed above, another more subtle facet of water quality deterioration is related to land drainage and man's activities in the watershed. Such essentially land-based operations as farming, road construction, logging, mining and recreation can cause quality deterioration. For projection purposes, loads from these and other potential land drainage sources are considered to be covered in the BOD of uncontrolled urban runoff. Return flow data for other similar areas and conditions indicate BOD to be relatively minor, generally resulting in less than 1.0 mg/l in the receiving stream. With continuance of proper land practices in the study area in the future, the possible detrimental effects of return irrigation flows can be minimized.

TABLE VIII-2
MAJOR INDUSTRIAL PLANTS
SKAGIT RIVER BASIN

Industrial Plant	Location	Raw Waste PE	Discharged Waste PE	Treatment	Receiving Body
Carnation Milk Co.	Mt. Vernon	3,300	2,100	City	Skagit R.
Mt. Vernon Meat Co.	"	800	0	Septic Tank	Land
Northwest Darigold	"	3,200	3,200	None	Skagit R.
Sakuma Brothers	"	1,200	0	Primary	Land
Stokely Van Camp	"	74,000	74,000	None	Skagit R.
Libby,McNeil & Libby	"	56,000	44,000	City	"
Galbreath Packing Co.	Burlington	1,400	0	Land	Land
Skagit Cty Dairymen's Association	"	6,000	6,000	None	Skagit R.
Cascade Frozen Foods	"	57,000	57,000	None	"
National Fruit Canning	"	27,000	27,000	None	"
Willis, Rogers and Pearson	Sedro Woolley	X	X	Pond	
Skagit Steel & Iron Wks	"	X Inorganic		Neutralization ponds for oil separation	
Avon Packing Co.	Avon	800	0	Septic Tank	Land
Frigid Food Products	"	15,000	15,000	None	Skagit R.
Summit View Lumber Co.	Darrington	X	0	Pond	--
Three Rivers Plywood & Timber Co.	"	X	0	Pond	--
Lone Star Cement Co.	Concrete	X Inorganic		X	--
San Juan Island Cannery	La Conner	45,000	45,000	None	Swinomish Slough
McRae Packing Co.	Edison	1,700	1,700	None	Edison Slough
Whidbey Island Harbor Custom Cannery	Freeland	X	X	Septic Tank	Puget Sound

TABLE VIII-3
PRESENT AND PROJECTED M&I WASTE LOADS
SKAGIT RIVER BASIN

	Present		1980		2000		2020	
	Raw	Disch.	Raw	Disch.	Raw	Disch.	Raw	Disch.
Municipal 1/	19,300	12,000	24,400	3,660	31,000	4,650	39,400	6,000
Food Processing 2/	245,700	228,300	330,000	49,500	445,000	66,850	600,000	90,000
TOTALS	265,000	240,300	354,400	53,160	476,000	71,500	639,400	96,000

1/ Projected @ 1.2%/yr for 20 yrs. - 1.2694 x 19,300 = 24,400.

2/ Food processing raw waste loads were projected at the rate of 1.5%/yr. or a growth factor of 1.3469 for a 20-year period.

C. WATER QUALITY OBJECTIVES

Water quality objectives for the various water uses to be served are discussed as follows:

1. Dissolved Oxygen

The dissolved oxygen (DO) objective for the Skagit River is dependent upon anadromous fishery requirements--the use requiring the highest DO level. Other uses served at this level are recreation and aesthetic conditions. Maintenance of 5 mg/l of dissolved oxygen would provide suitable conditions for anadromous fish passage while 7 mg/l provides adequate conditions for rearing. Spawning areas, however, require dissolved oxygen at saturation levels.

2. Temperature

Temperature requirements for the Skagit River are governed primarily by the anadromous fishery. Maximum temperatures should not exceed 70°F during July and August, to facilitate fish migration, holding, and rearing; by mid-September, temperatures should not exceed 57°F to obtain optimum egg survival.

3. Bacteria

Bacterial objectives for recreation and water supply use are 1,000 MPN and 5,000 MPN, respectively. Treatment, including disinfection, is required to reduce bacterial concentrations.

D. FLOW REGULATION

Utilizing present streamflow data and future waste loadings introduced as a single point loading at Mt. Vernon, oxygen balance computations show that adequate dissolved oxygen conditions for fish passage and rearing can be maintained in Skagit River without specific provisions for flow regulation. Utilizing a dissolved oxygen objective of 7 mg/l, considered to be adequate for anadromous fish passage and rearing, the flow required to assimilate maximum projected waste loadings (96,000 PE for year 2020) during the food processing season, assuming adequate treatment, is 250 cfs. The annual average 1-in-10 year low flow of the Mt. Vernon gaging station (12,100 cfs), and the minimum monthly 1-in-10 year low flow (occurring in the month of September) of 6,550 cfs are both in great excess of the flow required for waste assimilation. Discharge records show that the minimum recorded flow in the Skagit River near Mt. Vernon was 2,740 cfs on October 26, 1942. This flow, even with allowances for considerable future diversions, is more than sufficient for waste assimilation purposes.

The physical, chemical and biological quality of Skagit River waters are presently adequate for full stream utilization. Any developments which might tend to change these quality characteristics, however, should be examined at such time as specific project feasibility determinations may be made.

IX. BENEFITS....Water Quality Control

A. WATER SUPPLY

As foreseen within the scope of this reconnaissance investigation, no needs for M&I water supply storage and, therefore, no benefits applicable to possible Corps of Engineers' reservoirs in Skagit River Basin for this purpose are indicated at this time.

B. WATER QUALITY CONTROL

With adequate treatment or other means of controlling waste at the source, water quality for municipal and industrial supply, fisheries, wildlife and recreation can be maintained in Skagit River Basin without releases from storage for this purpose. No water quality control benefits applicable to possible Corps of Engineers' reservoirs in Skagit River Basin, therefore, are foreseen.

X. BIBLIOGRAPHY

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APPENDIX

Water Quality

APPENDIX A

WATER QUALITY, SKAGIT RIVER BASIN

River	Sampling Point		Temp.	pH	Dissolved Oxygen	Hardness (as $CaCO_3$)	Dissolved Solids	Nitrate	Phosphate	Coliform Bacteria MPN per 100 ml
Skagit	Marblemount RM 78	Max.	54	8.0	13.1	30	42	1.1	0.06	91
		Min.	39	6.9	10.1	18	23	0.0	0.00	< 23
		Ave.	47	7.4	11.8	23	33	0.3	0.01	--
		Med.	--	---	----	--	--	--	---	29
Sauk	Darrington RM 21	Max.	55	7.9	13.7	31	42	0.9	0.08	91
		Min.	37	5.7	10.4	12	18	0.0	0.00	< 23
		Ave.	45	7.1	12.0	19	30	0.2	0.02	--
		Med.	--	----	----	--	--	---	----	< 23
Skagit	Mt. Vernon RM 14	Max.	57	8.1	12.9	30	46	1.5	0.07	2,400
		Min.	39	6.9	9.3	15	23	0.0	0.00	30
		Ave.	47	7.2	11.2	22	35	0.4	0.02	--
		Med.	--	---	----	--	--	---	----	230

SOURCE: North Cascades Study.

APPENDIX A

SELECTED WATER QUALITY DATA,[1/] SKAGIT RIVER BASIN
SKAGIT RIVER AT MT. VERNON

Date	Fe	Ca	Mg	CO_3	SO_4	F	NO_3	PO_4	Hardness as $CaCO_3$ Ca&Mg	Hardness as $CaCO_3$ Non-CO_3	pH	Color Units	Temp. °C	DO	MPN
7/21/60	.06	5.5	1.0	0	3.2	.1	.1	.03	18	1	7.2	5	14.5	10.4	2,400
8/2/60	.12	6.5	0.3	0	3.4	.0	.0	.02	18	0	7.2	5	13.3	10.5	4,600
9/7/60	.15	6.0	1.1	0	3.6	.0	.3	.01	20	0	7.1	5	13.5	10.3	930
10/4/60	.15	7.0	1.0	0	4.8	.1	.2	.02	22	2	7.2	5	13.5	10.4	4,600
11/4/60	.09	7.5	0.8	0	4.4	.0	.4	.01	22	0	7.3	5	8.0	11.3	150
11/30/60	.10	8.0	1.6	0	5.4	.0	.5	.04	26	2	7.4	10	6.9	11.5	230
1/4/61	.08	8.0	1.4	0	5.2	.0	.3	.01	26	2	7.1	10	5.2	12.3	430
2/2/61	.39	7.0	1.3	0	3.0	.1	.4	.03	23	1	7.3	10	6.0	12.1	150
3/6/61	.40	8.5	1.5	0	4.8	.1	.4	.03	27	1	7.1	5	5.0	11.8	430
4/19/61	.06	8.0	1.5	0	4.4	.1	.3	.02	26	0	7.2	5	7.6	11.9	150
5/3/61	.24	7.0	0.9	0	4.0	.1	.3	.01	21	0	7.5	5	8.1	11.3	91
6/6/61	.28	5.0	1.0	0	3.6	.0	.3	.01	16	0	7.0	5	12.0	10.9	91
7/6/61	.46	5.5	0.7	0	2.8	.1	.2	.02	16	0	7.2	5	12.0	10.6	750
8/3/61	.10	5.5	1.2	0	4.4	.1	.1	.02	18	2	7.0	5	17.8	10.0	11,000
9/6/61	.36	5.5	0.9	0	4.2	.1	.1	.02	18	0	7.0	5	14.5	9.3	4,600
10/9/61	.21	7.0	0.9	0	5.4	.1	.3	.06	21	2	7.0	5	10.1	10.7	4,600
11/2/61	.10	7.0	1.1	0	5.0	.0	.4	.02	22	2	7.2	5	6.5	11.8	91
12/5/61	.25	6.5	1.2	0	4.4	.1	.5	.00	21	2	7.1	10	6.0	10.5	230
1/9/62	1.00	5.5	1.2	0	4.2	.1	.7	.00	18	2	7.0	10	6.0	11.9	91
2/8/62	.10	7.5	1.1	0	4.0	.1	.0	.01	23	0	7.1	5	6.7	11.8	230
3/8/62	.24	9.0	1.4	0	4.8	.1	.5	.02	28	0	7.0	5	6.4	11.9	2,400
4/2/62	.14	8.0	1.5	0	3.6	.1	.3	.02	26	0	7.3	5	---	11.5	2,400
5/4/62	.24	6.5	1.0	0	3.4	.1	.2	.00	20	0	7.1	5	6.2	11.6	36
6/13/62	.16	6.0	0.8	0	3.8	.1	.2	.02	18	0	7.1	5	12.0	10.6	3

(continued)

SKAGIT RIVER AT MT. VERNON (Continued)

Date	Fe	Ca	Mg	CO_3	SO_4	F	NO_3	PO_4	Hardness as $CaCO_3$ Ca&Mg	Hardness as $CaCO_3$ Non-CO_3	pH	Color Units	Temp. °C	DO	MPN
7/9/62	.14	5.0	0.8	0	3.2	.1	.1	.02	16	0	7.0	5	13.2	10.1	11,000
8/14/62	.08	6.5	0.7	0	4.4	.0	.3	.01	19	0	7.2	5	15.4	9.6	≤24,000
9/5/62	.15	7.0	1.0	0	3.8	.1	.2	.02	22	1	7.2	5	13.8	9.7	300
10/8/62	.21	6.5	1.4	0	5.0	.1	.3	.02	22	2	7.3	10	9.8	10.9	930
11/9/62	.13	7.0	1.0	0	4.6	.0	.3	.04	22	1	7.1	5	10.2	10.4	11,000
12/6/62	1.40	6.5	0.9	0	4.6	.1	.3	.02	20	2	6.9	10	6.8	13.7	91
1/3/63	1.70	6.0	0.7	0	2.0	.1	.3	.02	18	0	6.3	20	6.5	11.4	91
2/7/63	.82	6.0	0.8	0	2.8	.0	.4	.01	18	2	7.2	5	6.0	12.0	430
3/6/63	.06	8.5	1.2	-	3.8	.1	.4	.00	26	0	7.2	5	6.8	12.1	≤23
4/1/63	.13	9.0	1.2	0	4.4	.0	.5	.02	28	2	7.4	5	7.0	11.8	≤23
5/2/63	.30	8.0	1.5	0	4.6	.0	.4	.01	26	2	7.6	10	7.8	11.4	36
6/12/63	.22	6.0	1.1	0	3.6	.0	.2	.00	20	2	7.1	5	12.8	10.7	930
7/9/63	.20	6.0	1.0	0	3.6	.1	.3	.01	19	0	7.0	5	13.3	10.6	11,000
8/14/63	2.00	5.5	1.1	0	3.4	.0	.3	.01	18	2	7.0	5	15.0	9.8	24,000
9/3/63	.41	6.5	1.1	0	4.0	.2	.1	.01	20	1	7.1	5	16.0	9.5	---
10/30/63	.63	7.0	1.2	0	5.0	.1	.7	.01	22	2	7.1	5	9.0	10.9	230
11/12/63	---	---	---	-	---	--	--	---	--	-	---	-	9.1	10.6	2,400
12/9/63	.27	8.0	1.3	0	4.8	.1	.9	.01	25	1	6.9	5	5.6	11.5	230
1/14/64	.25	8.0	1.5	0	5.2	.0	.7	.01	26	2	7.3	5	5.2	12.0	432
2/20/64	.12	10.0	1.1	0	4.6	.1	.6	.01	30	2	7.1	5	6.0	13.1	36
3/27/64	.18	8.5	1.7	0	5.8	.1	.6	.01	28	2	7.5	5	5.4	12.3	150
4/24/64	.12	9.0	1.9	0	4.4	.1	.4	.01	30	2	7.3	5	10.0	11.4	36
6/2/64	1.10	4.5	1.0	0	2.6	.0	.4	.00	15	0	7.0	5	8.7	11.8	230
6/30/64	.38	5.5	1.4	0	3.0	.1	.3	.01	20	2	7.1	5	12.5	10.8	73
7/14/64	.73	5.0	0.7	0	3.4	.1	.3	.00	15	0	7.2	5	13.0	13.0	4,600
8/25/64	.13	5.5	0.7	0	3.8	.0	.2	.01	16	0	7.1	0	12.5	11.2	91
9/28/64	---	---	---	-	---	--	--	---	--	-	---	-	11.4	10.8	930

SOURCE: U. S. Geological Survey data.
1/ mg/l except as noted.

APPENDIX A

SELECTED WATER QUALITY DATA, SKAGIT RIVER BASIN
SKAGIT RIVER AT MARBLEMOUNT

Date of Collection	Fe	Ca	Mg	CO_3	SO_4	F	NO_3	PO_4	Hardness as $CaCO_3$ Ca&Mg	Hardness as $CaCO_3$ Non-CO_3	pH	Color Units	Temp. °C	DO	MPN
7/22/60	.08	6.0	0.5	0	2.8	.0	.0	.00	17	0	7.4	5	11.0	11.4	≦ 23
10/5/60	.05	7.5	0.8	0	4.0	.0	.2	.01	22	1	7.2	5	10.5	11.0	91
1/3/61	.05	9.0	1.4	0	3.8	.0	.2	.01	28	2	7.5	5	5.5	11.9	≦ 23
4/20/61	.01	9.5	0.7	0	4.0	.1	.2	.00	26	1	7.4	5	6.2	12.5	36
7/6/61	.11	7.0	0.7	0	3.6	.0	.2	.01	20	0	7.3	5	15.2	11.6	≦ 23
11/2/61	.02	6.5	0.7	0	3.2	.0	.3	.01	19	0	7.3	5	7.0	12.4	36
11/13/61	.09	7.0	0.6	0	4.0	.0	.3	.01	20	1	7.0	5	8.4	12.1	91
2/7/62	.08	7.0	0.6	0	3.8	.0	.5	.00	20	0	7.2	5	5.0	12.0	≦ 23
5/3/62	.03	8.0	0.8	0	3.8	.1	.2	.00	23	2	7.1	5	6.2	12.1	91
8/15/62	.06	6.5	0.8	0	3.0	.0	.3	.01	20	0	7.6	5	10.2	9.7	≧ 23
11/9/62	.03	8.0	0.4	0	4.0	.1	.1	.00	22	2	7.3	5	8.5	10.5	30
2/7/63	.14	4.5	0.7	0	2.2	.1	.4	.01	14	1	6.8	5	4.3	12.1	≦ 23
5/2/63	.02	9.5	0.9	0	4.6	.1	.3	.00	27	2	7.2	5	6.3	12.2	≦ 23
8/14/63	.23	7.0	0.4	0	3.4	.1	.2	.02	19	0	7.4	5	12.2	10.7	36
2/20/64	.04	10.0	1.3	0	5.2	.1	.2	.00	30	2	7.0	5	6.0	13.1	≧ 23
6/1/64	.14	5.5	0.9	0	2.4	.0	.4	.08	17	0	7.1	5	8.5	12.1	≧ 23
8/25/64	.09	7.0	0.6	0	3.4	.0	.3	.01	20	0	7.3	0	11.0	10.4	230

SOURCE: U. S. Geological Survey Data.

APPENDIX A

SELECTED WATER QUALITY DATA, SKAGIT RIVER BASIN
SAUK RIVER AT DARRINGTON

Date of Collection	Fe	Ca	Mg	CO_3	SO_4	F	NO_3	PO_4	Hardness as $CaCO_3$ Ca&Mg	Hardness as $CaCO_3$ Non-CO_3	pH	Color Units	Temp. °C	DO	MPN
7/22/60	.06	4.0	0.5	0	3.0	.0	.0	.02	12	0	7.2	5	12.5	10.6	≤ 23
10/5/60	.04	7.0	1.5	0	7.0	.1	.2	.02	24	0	7.5	5	11.0	11.3	≤23
1/3/61	.01	7.0	1.3	0	5.2	.0	.2	.02	23	0	7.3	5	2.0	12.9	≤23
4/20/61	.02	6.0	0.9	0	3.6	.0	.1	.01	18	0	7.1	5	5.2	12.8	2,400
7/6/61	.13	4.0	0.2	0	2.4	.0	.1	.02	11	0	7.3	5	10.0	11.2	36

SOURCE: U. S. Geological Survey data.

APPENDIX B
MUNICIPAL AND INDUSTRIAL WATER SUPPLY INVENTORY
SKAGIT RIVER BASIN

Water Supply	Ownership	Est. Pop. Served	Source	Treatment	Ave. Daily Use
Anacortes	Mun	10,000	2 Ranney wells & Skagit River	Filtration, Disinfection	13.000
Scott	Ind		Anacortes		5.300
Shell	Ind		Anacortes		3.300
Texaco	Inc.		Anacortes		3.300
Fidalgo Water System (PUD #1 Skagit Co.)	PUD	1,000	Anacortes		*0.014
LaConner Water Dept.	Mun	940	Anacortes		0.110
Naval Air Station	Fed	4,800	Anacortes		0.960
Delmar Community Service, Inc	NP	260	4 wells & 3 springs	None	0.015
Fallen Trenholme Community Water System	Coop	24	1 well	Disinfection	*0.003
Snee-Oosh Land Co.	NP	186	4 wells	Disinfection	0.018
USCG Light Station, Borrows Island	Fed		1 spring	Filtration & Disinfection	*0.001
Alger Community Water System	NP	70	1 well	None	0.004
Baker River Power, Light & Water Co. - Concrete	Pvt	875	Springs & Lake Shannon	Disinfection	*0.012
Blanchard-Edison Water Assoc.	NP	750		Disinfection	0.075
Darrington Water Works	Pvt	300	3 wells & Browns Creek	Disinfection	0.150
Diablo Water System	Mun	200	1 well		*0.020
Hamilton	Mun	200	1 well	None	0.036
Lyman	Mun	450	Jones Creek & standby well	None	0.021
Newhalem Water System	Mun	150	1 well		*0.015
Rockport	Pvt	42	Unnamed stream	None	*0.006
Samish Island Water Co.	NP	46	1 well		*0.006

APPENDIX B
MUNICIPAL AND INDUSTRIAL WATER SUPPLY INVENTORY
SKAGIT RIVER BASIN
(Continued)

Water Supply	Ownership	Est. Pop. Served	Source	Treatment	Ave. Daily Use
Skagit County PUD #1	PUD	27,800	2 wells, Turner, Mundt Gilligam, & Salmon Cr.	Disinfection	3.000
Mount Vernon			PUD #1		
Burlington			PUD #1		
Sedro Woolley			PUD #1		
Northern State Hospital	State	1,685	2 wells	Disinfection, Filtration	0.410
Wickersham Station, Sedro-Woolley	Pvt	80	Unnamed stream	None	0.005
Big Lake - Mt. Vernon	NP	101	Big Lake	Filtration	*0.014
Big Lake Water Co.	NP	52	Big Lake	Disinfection, Filtration	0.020
Cedardale Water Co..	Coop	33	Sand Creek	None	*0.004
Headquarters Water Assoc.	NP	58	1 spring	None	0.003
Hermway Heights	Pvt	27	1 spring & Lake 16	Disinfection	*0.004
Lower Cedardale Water Co.	NP	45	2 wells & 2 springs & Johnson Creek		*0.006
Mount Borne Improvement Club	NP	110	Big Lake	Disinfection	0.004

* Estimated

APPENDIX B
MUNICIPAL AND INDUSTRIAL WATER SUPPLY INVENTORY
WHIDBEY ISLAND

Water Supply	Ownership	Est. Pop. Served	Source	Treatment	Ave. Daily Use
Baby Island Water	Pvt	126	2 wells	None	0.002
Bonnie View Water Co., Inc.	NP	25	1 well	None	0.002
Bush Point Park Water Co.,Inc	NP	48	1 well	None	*0.004
Camp Lagoon	Pvt	85	1 well	None	0.006
Cascade View Road Water Assoc	NP	22	3 wells	None	*0.002
Clinton Water District	WD	420	1 well	Disinfection	0.030
Coupeville Water Dept.	Mun	1,200	3 wells	Disinfection	*0.011
Dugualla Community, Inc.	NP	60	1 well & 1 spring	None	*0.005
Glenwood Beach Water System	Coop	4	1 spring	None	0.001
Glenwood Beach Water Dist.	WD	24	1 spring	Disinfection	0.004
Greenbank Beach Water Co.	NP	55	1 well	None	0.010
H & H Properties, Inc.	Pvt	10	1 well	None	0.001
Hide-A-Way Water Co., Inc.	NP	81	1 well	None	0.014
Hillcrest Village Water Co.	NP	450	3 wells	Disinfection & Fluoridation	*0.040
Holmes Harbor Estates, Inc.	NP	200	1 well		*0.018
Hope View Water Co., Inc.	NP	15	1 well	None	0.001
Kohlwes, Tom	Pvt	50	1 well	None	0.020
Lagoon Point Water Co.	NP	250	1 well	None	0.010
Langley	Mun	455	3 wells	None	0.144
Laverne Park	Pvt	81	2 wells	None	0.008
Ledgewood Beach Water Assoc.	NP	50	1 well	None	*0.004
Long Point Manor Water Co.	NP	102	2 wells	None	0.005
Mabana Shores Water Assoc.	NP	43	1 well	None	0.001
Mutiny Bay Shores Water Assoc	Coop	40	1 well	None	*0.004
Mutiny Sands Club	NP	125	1 well	None	*0.011
Naval Air Station	Fed	4,800	Anacortes		0.960

APPENDIX B
MUNICIPAL AND INDUSTRIAL WATER SUPPLY INVENTORY
WHIDBEY ISLAND
(Continued)

Water Supply	Ownership	Est. Pop. Served	Source	Treatment	Ave. Daily Use
Oak Harbor	Mun	4,541	8 wells	Fluoridation	0.350
Penn Cove Park Water Dist.	WD	250	1 well	Disinfection, Fluoridation, Softening	0.021
Rolling Hills-Glencairn Community Service, Inc.	NP	150	1 well	Disinfection, Aeration	*0.013
Sandy Hook Yacht Club Estates	NP	100	1 well	None	*0.009
Saratoga Water	Pvt	219	1 well	None	0.004
Shangri-la Shores, Inc.	NP	65	1 well	None	*0.006
Sunrise Point Water Co.	NP	66	1 well	None	0.001
Smith, Roy A.	Pvt	50	1 well	None	0.002
South Whidbey State Park	Pvt.	20,000 visitors	1 well	None	0.002
Telaker Shores Water Co.	NP	26	1 well	None	*0.002
Tyee Beach Improvement Club	NP	340	2 wells & 1 spring	None	*0.007
Utsalady Point Water System	NP	78	4 springs	None	*0.007
Bayview Beach Water Dist.	Mun		1 well		

* Estimated

APPENDIX C

GROUND WATER QUALITY
ISLAND COUNTY

Owner	Well Location Code	Date	Temp °F	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Orthophosphate (PO_4)	Dissolved Solids 1/	Hardness (as $CaCO_3$)	Specific Conductance 2/	pH
Mutiny Sands, Inc.	29/2-9Q	5/19/60	50	47	.12	23	16	11	3.2	155	0	8.4	11	.1	.0	.20	181	122	292	7.9
		9/29/60	55	--	--	--	--	--	--	161	0	--	--	--	--	--	--	130	297	7.8
Green Community Progressive Club	30/2-8J	4/25/61	53	29	.04	8.0	13	15	1.4	94	0	11	10	.1	5.2	.00	14	72	208	7.5
City of Coupeville	32/1-33J1	5/10/60	55	36	.09	82	61	51	11	490	0	47	82	.2	.1	.35	595	454	1,040	7.7
		9/29/60	53	27	.69t	90	152	73	16	682	0	230	150	.2	.0	.37	1,100	849	1,720	7.7
		4/25/61	52	--	--	66	178	--	--	696	0	--	--	--	--	--	--	895	1,720	8.0
Arrowhead Beach, Inc.	32/3-18A1	5/19/60	50	37	.07	39	19	120	6.6	170	0	27	185	.2	.5	.09	516	174	937	7.6
		9/27/60	51	31	.19	40	18	136	6.9	168	0	26	220	.2	.4	.10	575	174	986	7.4
		4/24/61	51	31	.26	33	16	79	5.3	173	0	20	112	.2	.6	.07	411	149	679	7.6
New Utsallady Water System	32/3-19C	5/19/60	50	38	.01	45	20	14	6.0	229	0	16	16	.2	1.0	.36	254	194	433	7.7
		9/27/60	--	--	--	--	--	--	--	226	0	--	--	--	--	--	--	192	439	7.6

1/ Residue on evaporation at 180° C

2/ Micromhos at 25° C

Iron: Total iron concentrations are followed by a "t." All other values represent iron in solution at the time of sample collection.

Source: GROUND WATER IN WASHINGTON, ITS CHEMICAL AND PHYSICAL QUALITY, Water Supply Bulletin No. 24, Washington State Department of Conservation

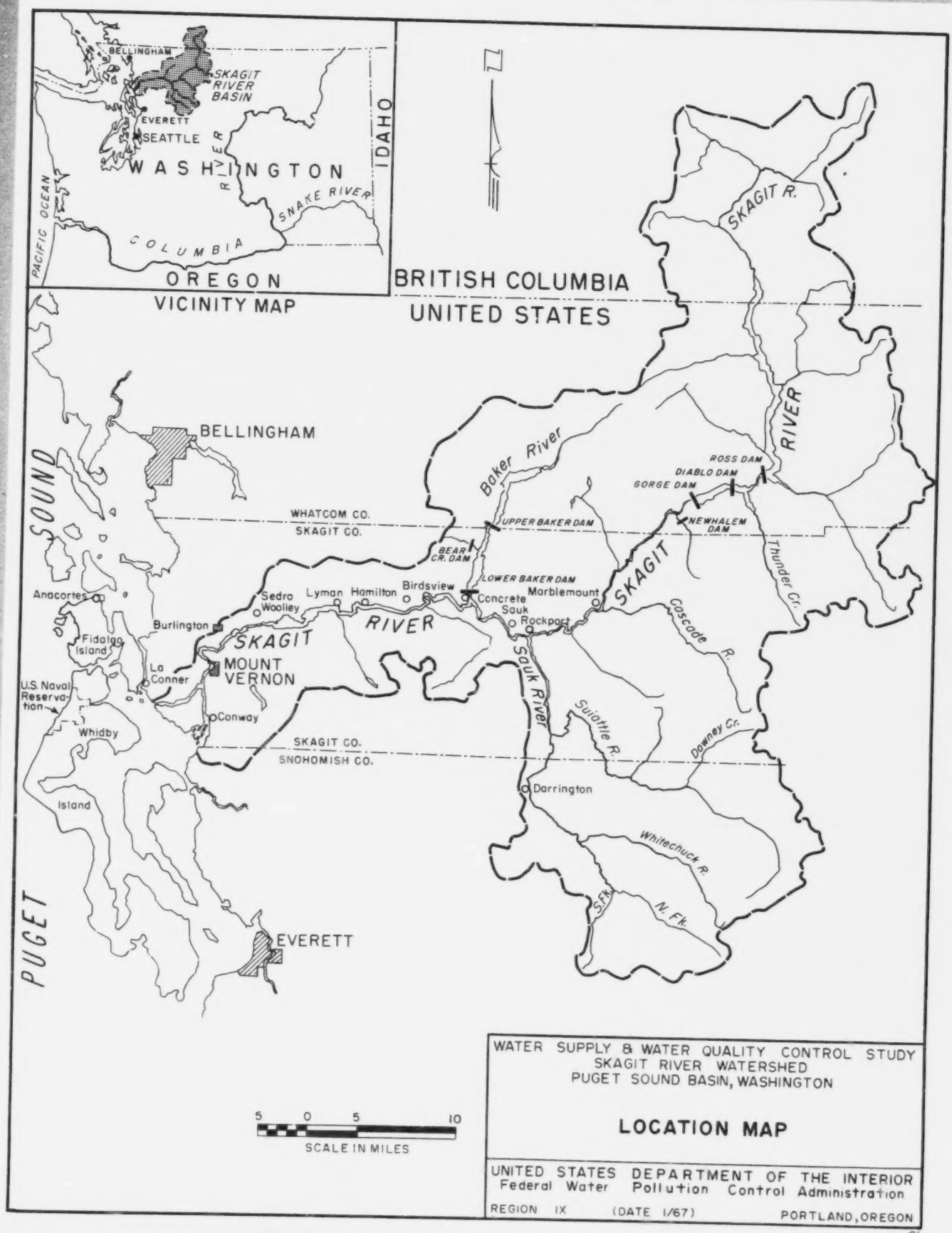
APPENDIX C
GROUND WATER QUALITY
S K A G I T C O U N T Y

Owner	Well Location Code	Date	Temp °F	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Orthophosphate (PO_4)	Dissolved Solids 1/	Hardness (as $CaCO_3$)	Specific Conductance 2/	pH
Oscar Denton	33/3-5H1	11/21/49	--	--	.05	--	--	--	--	358	0	20	34	.2	18	--	--	320	708	--
H. A. Galbraith	33/4-33D1	11/21/49	--	--	.03	--	--	--	--	136	0	2.0	6.0	.2	.0	--	--	94	233	--
N. Fortin	34/4-7P1	11/21/49	--	--	.03	--	--	--	--	60	0	9.0	13	.2	20	--	--	84	237	--
M. C. Turley	34/4-16F1	11/21/49	--	--	.02	--	--	--	--	602	45	52	78	.6	.2	--	--	32	1,320	--
M. C. Holmgrem	34/4-33P1	11/21/49	--	--	.03	--	--	--	--	194	0	14	22	.2	.0	--	--	154	385	--
L. H. Routan	35/3-11R1	11/21/49	--	--	.03	--	--	--	--	322	0	16	216	.3	1.1	--	--	142	1,180	--
Water Refineries, Inc.	35/4-32P	12/17/59	50	59	35	9.0	9.6	37	3.1	144	0	.5	29	.2	.2	.09	230	62	318	6.3
		5/18/60	52	--	--	--	--	--	--	131	0	--	--	--	--	--	--	65	295	6.2
State of Washington (well 6)	35/5-8D1	12/17/59	52	32	.44	23	11	23	3.2	142	0	.7	27	.2	.0	.36	181	101	315	7.7
		5/18/60	51	--	--	--	--	--	--	145	0	--	--	--	--	--	--	104	309	7.9
Skagit County Public Utility Dist. No. 1	35/5-30M1	4/18/52	--	43	.02	14	8.3	8.0	3.1	75	0	10	7.3	.1	8.2	--	138	69	176	7.0

1/ Residue on evaporation at 180° C

2/ Micromhos at 25° C

Source: GROUND WATER IN WASHINGTON, ITS CHEMICAL AND PHYSICAL QUALITY, Water Supply Bulletin No. 24, Washington State Department of Conservation



WATER SUPPLY & WATER QUALITY CONTROL STUDY
SKAGIT RIVER WATERSHED
PUGET SOUND BASIN, WASHINGTON

LOCATION MAP

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration

REGION IX (DATE 1/67) PORTLAND, OREGON